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Investigation of the Properties and Composition of a Concentrate of Spent Inkam-1 Emulsion as a Corrosion Inhibitor

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Abstract—The processing of discharge cutting fluids by membrane methods yields a concentrate consisting of petroleum products and surfactants. A gas chromatography–mass spectrometry study of the chemical composition has revealed the presence in the concentrate of dicyclohexylamine, which is a corrosion inhibitor according to published data. Therefore, it has been proposed to use the concentrate as a steel corrosion inhibitor for oilfield equipment. The physicochemical properties of the inhibitor have been determined, and corrosion tests for steel of Steel 20 grade have been carried out using the gravimetric method. To improve the protective properties of the inhibitor, the spent-coolant concentrate has been treated with a 1 M NaOH solution (to increase the pH) and modified by admixing oxypropylated diethylene glycol. According to the testing data, the degree of protection of Steel 20 was 78.5%. The resulting concentrate can be used as an inhibitor to protect pipelines against the corrosive effects of formation water. The composition of additives that can enhance the inhibitory characteristics of the concentrate has also been determined by testing.

Keywords: water–oil emulsion, concentrate, corrosion inhibitor, corrosion rate, Laprol 302, dicyclohexylamine

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Spent cutting/cooling emulsions are 3–10% emulsol solutions composed of industrial oils, ethylene glycol, monoethanolamine, sodium nitrite, and other chemicals [1–3]. At metalworking and machining plants, both short-service-life and sufficiently persistent cutting fluids with a service life of several months are used. The most consumed cutting fluid at the production facilities affiliated with the KAMAZ truck factory is the emulsion known under the trademark Inkam-1. The Inkam-1 consumption volume is more than 4000 ton/year; other types of coolant are used in an amount of less than 1000 ton/year. In this connection, a spent Inkam-1 emulsion was chosen as the object of research. The initial emulsion of this coolant includes mineral oil, emulsifiers, a corrosion inhibitor, a bactericide, and water.

The technology developed previously for cleaning the spent Inkam-1 emulsion [4–6] includes the following steps: (1) separating free petroleum products and settling suspended solids in a coalescent purification unit, (2) sorption of dissolved petroleum products on a composite carbon adsorbent, and (3) isolating and concentrating petroleum products and surfactants on an ultrafiltration membrane module followed by post-treatment on a nanofiltration membrane unit. The treatment of the spent emulsion gives a concentrate, which must be disposed or recycled.

The aim of this work was to obtain a steel corrosion inhibitor based on the concentrated oil–water emulsion.

EXPERIMENTAL

The concentration of petroleum products and nonionic surfactants was determined by IR spectrometry using a KN-3 concentration meter. The water content and the amount of mechanical impurities were determined gravimetrically.

A gas chromatographic–mass spectrometric (GC–MS) study of the organic portion of the emulsion concentrate was carried out on a Thermo Scientific DFS instrument (Germany) in the electron ionization mode at an ionizing electron energy of 70 eV and an ion source temperature of 290°C. An ID-BP5X (analogue of DB-5MS) capillary column of 50 m in length and 0.32 mm in diameter, available from Scientific Glass Engineering (Australia), was used. The stationary phase was 5% biphenyl and 95% dimethylpolysiloxane in chemical composition. The film thickness was 0.25 μm. The carrier gas was helium. The mass spectral data were processed using the program Xcalibur. A sample of the liquid to be tested was diluted with chromatographically pure chloroform, ~5 vol %. Chromatograms were recorded at an injector tempera-